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(54) Abstract Title
Wavelength multiplexed optical signal amplification control system

(57) A wavelength multiplexed optical signal is input to an erbium doped fibre amplifier 3. A fraction of the input signal is split off at a coupler 1, demultiplexed by an arrayed waveguide 5, then the number of different wavelength signals in the multiplexed signal is detected by a photo detector array 9. This information, in combination with a standard feedback control system, 4 and 8, is used to control the level of amplification and to achieve a desired output level.

FIG.1

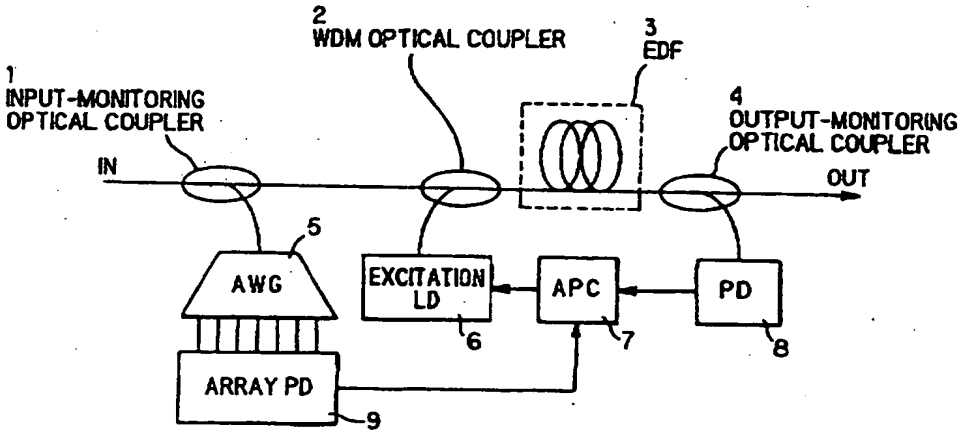

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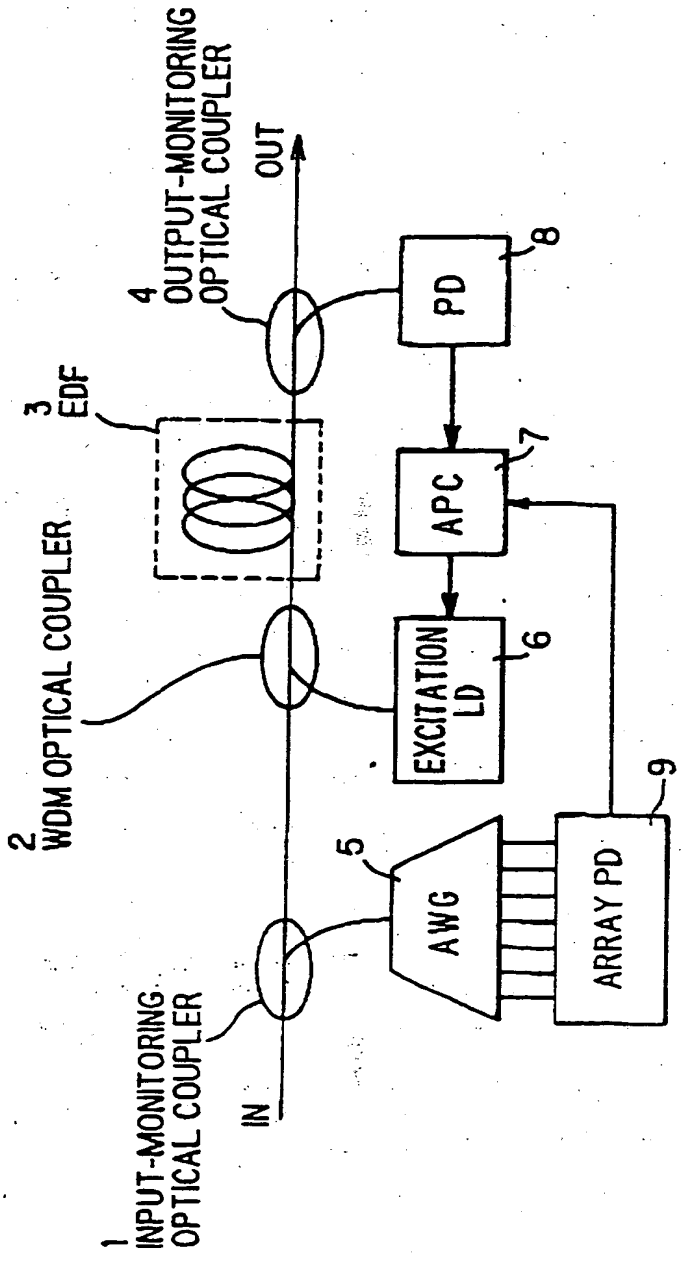
FIG. 1



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OPTICAL SIGNAL AMPLIFICATION CONTROL SYSTEM

FIELD OF THE INVENTION

This invention relates to an optical signal amplification control system for amplifying wavelength-multiplexed optical signal with different wavelengths to be transmitted through an optical fiber cable, and more particularly to, an optical signal amplification control system used in amplifying wavelength-multiplexed optical signal in the lump, that is to say without dividing it into its constituent parts, so that all wavelengths are amplified.

BACKGROUND OF THE INVENTION

It is well known that an optimum output power of optical signal is required in the long-distance transmission through an optical fiber cable since if the output power is too low or too high, problems are caused.

Therefore, in the long-distance transmission of an optical signal through an optical fiber cable, a wavelength-multiplexed signal is amplified in the lump to get an optimum output power by using repeating amplifiers placed at several repeating points.

The first one of conventional amplification control systems is operated by storing a predetermined reference level in a repeating amplifier, amplifying an optical signal to be input up to the reference level, then outputting it.

The second system is operated by transmitting wavelength multiplexing number information from a transmitting end to a repeating amplifier, conducting the amplifying of the repeating amplifier according to the wavelength multiplexing number information.

Meanwhile, in such a conventional optical signal amplification control system, the whole output power of a wavelength-multiplexed optical signal is controlled to be constant even when amplifying the optical signal where several signals with different wavelengths are wavelength-multiplexed.

However, in such controlling, the output power per each signal (wavelength) must be varied depending upon the number of multiplexed wavelengths. Namely, the larger the number of multiplexed wavelengths is, the more the light output power per one wavelength is reduced. The optimum output power per one wavelength must be varied depending upon the number of multiplexed wavelengths.

Thus, it is desired that a value of optimum output power can be determined according to the wavelength multiplexing number information when amplifying a wavelength-multiplexed signal. Also, it is desired that a value of optimum output power can be changed on real time according to a variation in the number of multiplexed wavelengths in such optical communication that the number of multiplexed wavelengths may be varied. However, the first system cannot be adapted to the variation in number of multiplexed wavelengths.

The second system requires transmitting wavelength multiplexing number information from a transmitting end to a repeating amplifier, thereby increasing the quantity of information to be transmitted through the optical fiber cable as well as complicating the system that much.

Also, when a light-wave network using only light is constructed in the future, the number of multiplexed wavelengths to be transmitted through an optical fiber cable will be dynamically varied.

In such case, the number of wavelengths in the second system is very difficult to manage.

Furthermore, wrong wavelength number information may be transmitted due to a noise etc. If the second system is controlled by such wrong information, the transmission error of an optical signal may occur.

SUMMARY OF THE INVENTION

Accordingly, it is an object of at least the preferred embodiments of the invention to provide an optical signal amplification control system that can conduct optimum controls on output power according to the number of multiplexed wavelengths without transmitting wavelength multiplexing number information from a transmitting end.

It is a further such object to provide an optical signal amplification control system that can conduct optimum controls on output power on real time even when the number of wavelengths in a wavelength-multiplexed optical signal to be input is dynamically varied.

According to the invention, an optical signal amplification control system for amplifying in the lump a wavelength-multiplexed signal that several optical signals with different wavelengths to be transmitted through an optical fiber cable are multiplexed, comprises:

means for detecting always the number of the different wavelengths multiplexed in the wavelength-multiplexed signal; and

means for amplifying in the lump the wavelength-multiplexed signal;

wherein the optical signal amplification control system

controls the amplifying means to amplify in the lump the wavelength-multiplexed signal up to a desired level according to the d tected number of the different wavelengths.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in more detail in conjunction with the appended drawings, wherein:

FIG.1 is a block diagram showing an optical signal amplification control system in a preferred embodiment according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An optical signal amplification control system in the preferred embodiment will be explained in FIG.1.

Referring to FIG.1, 1 is an input-monitoring optical coupler, 2 is a WDM (wavelength division multiplex) optical coupler for multiplexing an input signal and excitation laser light, and 3 is an erbium-doped fiber (EDF) which is obtained by doping erbium ion into an optical fiber and amplifies a 1.55 μm band optical signal when 1.48μm excitation light is supplied thereinto.

Further, 4 is an output-monitoring optical coupler, 5 is an arrayed wave guide (AWG) for demultiplexing wavelength-multiplexed light to be input into lights with different wavelengths, 6 is an excitation laser light source (hereinafter referred to as 'excitation LD'), 7 is an automatic output power control (APC) circuit, 8 is a photodetector (PD), and 9 is an arrayed photodetector (hereinafter referred to as 'array PD').

Meanwhile, a wavelength number detecting means, which is defined herein, is composed of the input-monitoring optical coupler

1, AWG 5 and the array PD 9. Also, an amplifying means, which is defined herein, is composed of the excitation LD 6, the WDM-optical coupler 2 and the erbium-doped fiber 3. Further, the control of the amplifying means according to the number of multiplexed wavelengths, which is defined herein, is conducted by the output-monitoring optical coupler 4 and the APC circuit 7 to which wavelength number information is input from the wavelength number detecting means.

In operation, an optical signal that several signals with different wavelengths are multiplexed (wavelength-multiplexed signal) is input to the input side (IN), and then part of the wavelength-multiplexed signal is separated from its main signal by the input-monitoring optical coupler 1, input to the arrayed wave guide (AWG) 5.

The arrayed wave guide (AWG) 5 divides the wavelength-multiplexed signal input thereto into several signals with different wavelengths, and the divided several signals with different wavelengths are received, as they are, by the arrayed photodetector (array PD) 9.

Thus, the number of wavelengths in the wavelength-multiplexed signal to be input to the input side (IN) can be detected.

Meanwhile, the input-monitoring optical coupler 1, arrayed wave guide (AWG) 5 and array PD 9 can be operated on real time. Therefore, even when the number of wavelengths in the wavelength-multiplexed signal to be input to the input side (IN) can be varied, the variation can be detected on real time.

Then, information about the number of wavelengths (number of signals) to be detected by the array PD 9 is sent to the APC circuit 7 to control automatically the light output power. The APC circuit

7 selects an optimum output power according to the number of wavelengths based upon this information, controlling the excitation LD 6 to provide the selected optimum output power.

On the other hand, the main signal is multiplexed with the optical output of the excitation LD 6 by the WDM optical coupler 2, input to EDF 3, amplified by the EDF 3, then output through the output-monitoring optical coupler 4 to the output side (OUT). At this time, part of the output signal is divided by the output-monitoring optical coupler 4, monitored of the output level by PD 8. The monitored information is then input to APC 7, thereby conducting feedback control.

Thus, APC 7 determines an optimum value of whole amplification level to the wavelength-multiplexed signal according to the multiplexing wavelength number information obtained from the array PD 9, and feedback-controls the control current of the excitation LD 6 so that the output signal level can have this optimum value while monitoring the output signal level.

Although, in this embodiment, the wavelength number detecting means is composed of the input-monitoring optical coupler 1, AWG 5 and the array PD 9, it is not limited to this composition. The wavelength number detecting means may be any means that is composed of means for separating part of a wavelength-multiplexed signal to be transmitted, means for dividing the separated part of the wavelength-multiplexed signal into lights with different wavelengths, and means for detecting the divided lights with different wavelengths to count the number of wavelengths.

Although, in this embodiment, the amplifying means is composed of the excitation LD 6, the WDM optical coupler 6 and the erbium-doped

fiber 3, it is not limited to this composition. The amplifying means may be any means that can amplify in the lump the wavelength-multiplexed signal up to a desir d level.

Although the invention has been described with respect to specific embodiment for complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modification and alternative constructions that may be occurred to one skilled in the art which fairly fall within the basic teaching here is set forth.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The description of the invention with reference to the drawings is by way of example only.

The text of the abstract filed herewith is repeated here as part of the specification.

Disclosed is an optical signal amplification control system for amplifying in the lump a wavelength–multiplexed signal that several optical signals with different wavelengths to be transmitted through an optical fiber cable are multiplexed, the system having: means for detecting always the number of the different wavelengths multiplexed in the wavelength–multiplexed signal; and means for amplifying in the lump the wavelength–multiplexed signal; wherein the optical signal amplification control system controls the amplifying means to amplify in the lump the wavelength–multiplexed signal up to a desired level according to the detected number of the different wavelengths.

What is claimed is:

1. An optical signal amplification control system for amplifying in the lump (as herein defined) a wavelength-multiplexed signal in which a plurality of optical signals with different wavelengths to be transmitted through an optical fiber cable are multiplexed, comprising:

means for detecting the number of said different wavelengths multiplexed in said wavelength-multiplexed signal; and

means for amplifying in the lump said wavelength-multiplexed signal;

wherein said optical signal amplification control system controls said amplifying means to amplify in the lump said wavelength-multiplexed signal up to a desired level according to said detected number of said different wavelengths.

2. An optical signal amplification control system, according to claim 1, wherein:

said wavelength number detecting means comprises means for separating part of said wavelength-multiplexed signal to be transmitted, means for dividing said separated part of said wavelength-multiplexed signal into lights with different wavelengths, and means for counting said number of said different wavelengths multiplexed in said wavelength-multiplexed signal by detecting said divided lights with different wavelengths.

3. An optical signal amplification control system, according to claim 2, wherein:

said separating means comprises an arrayed wave guide (AWG),

and said counting means comprises an arrayed photodetector.

4. An optical signal amplification control system, according to claim 1, wherein:

said amplifying means comprises an excitation laser light source, a WDM optical coupler to multiplex the excitation light from said excitation laser light source with said wavelength-multiplexed signal, and an erbium-doped fiber.

5. An optical signal amplification control system, according to claim 1, further comprising:

means for feedback-controlling said amplifying means to provide said wavelength-multiplexed signal to be output with said desired level according to said detected number of said different wavelengths while monitoring the output level after amplification.

6. An optical signal amplification control system, according to claim 5, wherein:

said feedback-controlling means determines said desired level according to said detected number of said different wavelengths and controls said amplifying means to amplify in the lump said wavelength-multiplexed signal up to said desired level.

7. A method of amplifying a wavelength-multiplexed optical signal comprising determining the number of different-wavelength constituents of the multiplexed signal, and amplifying the signal without demultiplexing it to a level dependent on the said number of constituents.

8. A control system or a method substantially as herein described with reference to or as shown in the accompanying drawings.

The Patent Office

Application No:	GB 9808861.0	**Examiner:**	Stephen Brown
Claims searched:	1-8	**Date of search:**	6 August 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4B (BK16, BK16D, BKX)

Int Cl (Ed.6): H04B: 10/16, 10/17, H04J: 14/02

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2 294 170 A	(Fujitsu) See especially the abstract and figures 12 & 15.	1-8
X	GB 2 280 561 A	(Northern Telecom) See especially the abstract.	1, 4, 7
X	EP 0 817 415 A2	(NEC) See especially the abstract.	1, 4-7
X	EP 0 812 078 A2	(Fujitsu) See especially the abstract.	1, 4-7
X	EP 0 801 475 A2	(NEC) See especially the abstract and figure 2.	1, 4-7
X	EP 0 782 289 A1	(NEC) See especially the abstract and figure 1.	1, 4-7

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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